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telescope at Yebes in May 1990

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INTRODUCTION

Previous holographic measurements, made in Autumn 1986, showed a pronounced astigmatism combined with an "S" shaped distortion probably due to gravitational effects. However no successful calibration was made and the orientation and sense of the maps of the aperture plane was unknown.

Since these initial measurements the telescope backup structure has been stiffened and an improved receiver has been installed.

The present measurements were intended to verify any changes in stiffness and to get a reliable calibration.

OBSERVATIONS

As for the previous measurements, total power maps of the telescope beam were made both in focus and defocused (by 200 milli-inches). Jupiter and Venus were used, being the strongest sources available. Quasi-continuum observations of the SiO maser sources were also attempted but the signal to noise ratio was inferior.

The maps (16x16 pixels) were made as a series of azimuth scans at different elevations separated by 56 arc seconds (the sampling interval). Thus the data sampling was at 0.552 of the critical Nyquist value.

The data was often dominated by baseline drifts associated with daytime clouds so that the scans were made as fast as possible (64 seconds) to reduce these effects to the minimum. As the "dead" time between azimuth scans was 12 seconds, the observing efficiency was "reasonable". Four of the 64 1 second samples were averaged and linear baselines were subtracted.

"Good" quality maps were selected, averaged, and processed by the Misell algorithm to produce maps of aperture plane phase and amplitude.

The calibration was achieved by making a series of maps with a 40 cm square plastic sheet attached to the subreflector. A section of the "Esscolam" radome material was used (0.03 inches thickness, dielectric constant 3) and was calculated to produce a phase change of about 0.9 radians. The resulting perturbation of the aperture plane phase maps was clearly seen. Viewed from the front of the telescope, the calibration sheet was in the top left hand corner (top right hand corner when viewed from the vertex of the main mirror).

RESULTS

The signal to noise ratio achieved was inferior to that of the 1986 results largely because the available planets were at a greater distance.

The aperture plane phase distributions derived from the Venus observations are shown in Figure 1 (with the plastic calibration sheet in place) and Figure 2. The calibration shows that these maps are front views with Blue (larger numbers) corresponding to depressions on the prime mirror surface (longer electrical paths).

Figures 3 and 4 are phase maps derived from the Jupiter measurements at two elevations, 66.7 degrees for Figure 3 and 35.7 degrees for Figure 4.

The best estimate of the telescope surface at intermediate elevations (about 40 degrees) is probably obtained by averaging the Venus and Jupiter results (Figures 2 and 4). The result is displayed in Figure 6.

For comparison the old data on Venus taken in 1986 have been reanalysed with improved pointing corrections and the results are shown in Figure 5 for the amplitude distribution and Figure 6 for the phase distribution.

DISCUSSION

The Venus and Jupiter observations taken this year are in good qualitative agreement - see Figures 2 and 4. However there do seem to be systematic differences from the earlier 1986 data (Compare Figure 5 with Figure 6). It will be noticed that the illumination taper is apparently higher for the May 1990 data (compare the upper plots in Figure 5 and 6). This may be accounted for by the larger angular diameter of the planets during the 1990 observations. This leads to a smoothing of the polar diagrams and thus an additional taper in the aperture plane. Thus the accuracy of the phase estimates are reduced near the edge of the telescope mirror.

There are also systematic phase differences visible on the lower plots of Figures 5 and 6. If these differences are real then they may indicate a change in the telescope shape after the stiffening operation on the backup structure.

This possibility raises the question of which data to use for a correction? The better quality data of 1986 which may no longer represent the present mirror shape, or the poorer quality data taken this May? It may possibly be wiser to use the present (May 1990) data of Figure 6, bearing in mind the enhanced errors near the edge of the mirror due to the larger effective taper.

With this in mind the aperture phase distribution has been listed in the Tables 1 and 2 for the two data sets. The values are given as X, Y, PHASE (radians). The origin of the coordinates is at the bottom left hand corner of the telescope aperture viewed from the FRONT. Then X increases from left to right and Y upwards. The values comprise a 32x32 array and outside the mirror limits they have been put to zero. Positive phases correspond to increased path length I.E. depressions, away from the focus, on the primary mirror.

An experimental correction could be made with a phase correction plate mounted on the secondary mirror. If this plate is made of some expanded plastic material of low effective dielectric constant several advantages would apply. Firstly the dimensions (thickness) become greater thus easing the precision requirements of the machining or cutting process. Secondly the reflective loss becomes small also. Expanded polystyrene or expanded teflon may be useful. For example, Emerson and Cumming make an expanded polystyrene "ECCOFOAM PS" with effective dielectric constant in the range 1.02 - 1.40 - 1.9. (Agents:- Grace Electric, Tour Parific, 6 Rue Emile Raynaud, 93306 AUBERVILLIERS Cedex)

FIGURE CAPTIONS

Figure 1

Aperture plane phase distribution measured on Venus with the plastic phase calibration sheet in place. Contour interval is 0.2 radians (107 microns). Contour number 5 is zero. Elevation 46.5 degrees, FRONT view.

Figure 2

Aperture plane phase distribution measured on Venus. Contour interval is 0.2 radians (107 microns). Contour number 5 is zero. Average elevation 44 degrees FRONT view,

Figure 3

Aperture plane phase distribution measured on Jupiter. Contour interval is 0.2 radians (107 microns). Contour number is 5 zero. Average elevation 66.7 degrees, FRONT view.

Figure 4

Aperture plane phase distribution measured on Jupiter. Contour interval is 0.2 radians (107 microns). Contour number 5 is zero. Average elevation 35.7

degrees, FRONT view.

Figure 5

Aperture plane distribution measured on Venus in 1986. The upper plot is the illumination pattern. Contour interval is 2 dB, number 9 being zero. The lower plot is of phase. Contour interval is 0.2 radians (107 microns). Contour number 5 is zero. Average elevation 35 degrees, FRONT view.

Figure 6

Average aperture plane distribution measured on Venus and Jupiter in 1990. The upper plot is the illumination pattern. Contour interval is 2 dB, number 9 being zero. The lower plot is of phase. Contour interval is 0.2 radians (107 microns). Contour number 5 is zero. Average elevation 40 degrees, FRONT view.

TABLE 1

Aperture phase results for May 1990 (venjupav2.phqse)

1	1	0.00	2	1	0.00	3	1	0.00	4	1	0.00	5	1	0.00	6	1	0.00
7	1	0.00	8	1	0.00	9	1	0.00	10	1	0.00	11	1	0.00	12	1	0.00
13	1	0.00	14	1	0.00	15	1	0.00	16	1	0.00	17	1	0.00	18	1	0.00
19	1	0.00	20	1	0.00	21	1	0.00	22	1	0.00	23	1	0.00	24	1	0.00
25	1	0.00	26	1	0.00	27	1	0.00	28	1	0.00	29	1	0.00	30	1	0.00
31	1	0.00	32	1	0.00	1	2	0.00	2	2	0.00	3	2	0.00	4	2	0.00
5	2	0.00	6	2	0.00	7	2	0.00	8	2	0.00	9	2	0.00	10	2	0.00
11	2	0.00	12	2	0.00	13	2	0.00	14	2	0.00	15	2	0.00	16	2	0.00
17	2	0.00	18	2	0.00	19	2	0.00	20	2	0.00	21	2	0.00	22	2	0.00
23	2	0.00	24	2	0.00	25	2	0.00	26	2	0.00	27	2	0.00	28	2	0.00
29	2	0.00	30	2	0.00	31	2	0.00	32	2	0.00	1	3	0.00	2	3	0.00
3	3	0.00	4	3	0.00	5	3	0.00	6	3	0.00	7	3	0.00	8	3	0.00
9	3	0.00	10	3	0.00	11	3	0.00	12	3	0.00	13	3	0.00	14	3	0.00
15	3	0.00	16	3	0.00	17	3	0.00	18	3	0.00	19	3	0.00	20	3	0.00
21	3	0.00	22	3	0.00	23	3	0.00	24	3	0.00	25	3	0.00	26	3	0.00
27	3	0.00	28	3	0.00	29	3	0.00	30	3	0.00	31	3	0.00	32	3	0.00
1	4	0.00	2	4	0.00	3	4	0.00	4	4	0.00	5	4	0.00	6	4	0.00
7	4	0.00	8	4	0.00	9	4	0.00	10	4	0.00	11	4	0.00	12	4	0.00
13	4	0.00	14	4	0.00	15	4	0.00	16	4	0.00	17	4	0.00	18	4	0.00
19	4	0.00	20	4	0.00	21	4	0.00	22	4	0.00	23	4	0.00	24	4	0.00
25	4	0.00	26	4	0.00	27	4	0.00	28	4	0.00	29	4	0.00	30	4	0.00
31	4	0.00	32	4	0.00	1	5	0.00	2	5	0.00	3	5	0.00	4	5	0.00
5	5	0.00	6	5	0.00	7	5	0.00	8	5	0.00	9	5	0.00	10	5	0.00
11	5	0.00	12	5	0.00	13	5	0.00	14	5	0.00	15	5	0.00	16	5	0.00
17	5	0.00	18	5	0.00	19	5	0.00	20	5	0.00	21	5	0.00	22	5	0.00
23	5	0.00	24	5	0.00	25	5	0.00	26	5	0.00	27	5	0.00	28	5	0.00
29	5	0.00	30	5	0.00	31	5	0.00	32	5	0.00	1	6	0.00	2	6	0.00
3	6	0.00	4	6	0.00	5	6	0.00	6	6	0.00	7	6	0.00	8	6	0.00
9	6	0.00	10	6	0.00	11	6	0.00	12	6	0.00	13	6	0.00	14	6	0.00
15	6	0.00	16	6	0.00	17	6	0.00	18	6	0.00	19	6	0.00	20	6	0.00
21	6	0.00	22	6	0.00	23	6	0.00	24	6	0.00	25	6	0.00	26	6	0.00
27	6	0.00	28	6	0.00	29	6	0.00	30	6	0.00	31	6	0.00	32	6	0.00
1	7	0.00	2	7	0.00	3	7	0.00	4	7	0.00	5	7	0.00	6	7	0.00
7	7	0.00	8	7	0.00	9	7	0.00	10	7	0.00	11	7	0.00	12	7	0.00
13	7	0.00	14	7	0.00	15	7	0.00	16	7	0.00	17	7	0.00	18	7	0.00
19	7	0.00	20	7	0.00	21	7	0.00	22	7	0.00	23	7	0.00	24	7	0.00
25	7	0.00	26	7	0.00	27	7	0.00	28	7	0.00	29	7	0.00	30	7	0.00
31	7	0.00	32	7	0.00	1	8	0.00	2	8	0.00	3	8	0.00	4	8	0.00
5	8	0.00	6	8	0.00	7	8	0.00	8	8	0.00	9	8	0.00	10	8	0.00
11	8	0.00	12	8	-2.60	13	8	-1.85	14	8	-1.56	15	8	-1.34	16	8	0.24
17	8	0.19	18	8	-0.37	19	8	-0.98	20	8	-1.62	21	8	0.00	22	8	0.00
23	8	0.00	24	8	0.00	25	8	0.00	26	8	0.00	27	8	0.00	28	8	0.00
29	8	0.00	30	8	0.00	31	8	0.00	32	8	0.00	1	9	0.00	2	9	0.00
3	9	0.00	4	9	0.00	5	9	0.00	6	9	0.00	7	9	0.00	8	9	0.00
9	9	0.00	10	9	0.00	11	9	-1.86	12	9	-1.66	13	9	-1.32	14	9	-0.94
15	9	-0.60	16	9	-0.15	17	9	0.19	18	9	0.09	19	9	-0.31	20	9	-0.85
21	9	-1.50	22	9	0.00	23	9	0.00	24	9	0.00	25	9	0.00	26	9	0.00
27	9	0.00	28	9	0.00	29	9	0.00	30	9	0.00	31	9	0.00	32	9	0.00
1	10	0.00	2	10	0.00	3	10	0.00	4	10	0.00	5	10	0.00	6	10	0.00
7	10	0.00	8	10	0.00	9	10	0.00	10	10	-0.41	11	10	-0.85	12	10	-0.96
13	10	-0.74	14	10	-0.28	15	10	-0.06	16	10	0.04	17	10	0.30	18	10	0.53
19	10	0.34	20	10	-0.14	21	10	-0.82	22	10	-1.73	23	10	0.00	24	10	0.00
25	10	0.00	26	10	0.00	27	10	0.00	28	10	0.00	29	10	0.00	30	10	0.00
31	10	0.00	32	10	0.00	1	11	0.00	2	11	0.00	3	11	0.00	4	11	0.00
5	11	0.00	6	11	0.00	7	11	0.00	8	11	0.00	9	11	-0.44	10	11	-0.38
11	11	-0.58	12	11	-0.63	13	11	-0.31	14	11	0.22	15	11	0.46	16	11	0.58
17	11	0.85	18	11	1.14	19	11	1.00	20	11	0.51	21	11	-0.19	22	11	-0.91

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23	11	-1.46	24	11	0.00	25	11	0.00	26	11	0.00	27	11	0.00	28	11	0.00
29	11	0.00	30	11	0.00	31	11	0.00	32	11	0.00	1	12	0.00	2	12	0.00
3	12	0.00	4	12	0.00	5	12	0.00	6	12	0.00	7	12	0.00	8	12	-1.76
9	12	-1.15	10	12	-0.76	11	12	-0.59	12	12	-0.43	13	12	-0.09	14	12	0.28
15	12	0.53	16	12	0.72	17	12	0.97	18	12	1.21	19	12	1.20	20	12	0.87
21	12	0.33	22	12	-0.26	23	12	-0.75	24	12	-1.00	25	12	0.00	26	12	0.00
27	12	0.00	28	12	0.00	29	12	0.00	30	12	0.00	31	12	0.00	32	12	0.00
1	13	0.00	2	13	0.00	3	13	0.00	4	13	0.00	5	13	0.00	6	13	0.00
7	13	0.00	8	13	-1.01	9	13	-1.03	10	13	-0.92	11	13	-0.59	12	13	-0.25
13	13	-0.09	14	13	0.03	15	13	0.17	16	13	0.34	17	13	0.50	18	13	0.65
19	13	0.76	20	13	0.76	21	13	0.60	22	13	0.28	23	13	-0.14	24	13	-0.55
25	13	0.00	26	13	0.00	27	13	0.00	28	13	0.00	29	13	0.00	30	13	0.00
31	13	0.00	32	13	0.00	1	14	0.00	2	14	0.00	3	14	0.00	4	14	0.00
5	14	0.00	6	14	0.00	7	14	0.00	8	14	-0.18	9	14	-0.61	10	14	-0.64
11	14	-0.42	12	14	-0.21	13	14	-0.21	14	14	-0.31	15	14	-0.37	16	14	-0.34
17	14	-0.24	18	14	-0.13	19	14	0.00	20	14	0.18	21	14	0.42	22	14	0.46
23	14	0.18	24	14	-0.29	25	14	0.00	26	14	0.00	27	14	0.00	28	14	0.00
29	14	0.00	30	14	0.00	31	14	0.00	32	14	0.00	1	15	0.00	2	15	0.00
3	15	0.00	4	15	0.00	5	15	0.00	6	15	0.00	7	15	0.00	8	15	0.20
9	15	-0.13	10	15	-0.26	11	15	-0.25	12	15	-0.24	13	15	-0.32	14	15	-0.55
15	15	-0.85	16	15	-0.98	17	15	-0.87	18	15	-0.65	19	15	-0.44	20	15	-0.25
21	15	-0.04	22	15	0.10	23	15	0.05	24	15	-0.12	25	15	0.00	26	15	0.00
27	15	0.00	28	15	0.00	29	15	0.00	30	15	0.00	31	15	0.00	32	15	0.00
1	16	0.00	2	16	0.00	3	16	0.00	4	16	0.00	5	16	0.00	6	16	0.00
7	16	0.00	8	16	0.32	9	16	0.11	10	16	0.02	11	16	-0.07	12	16	-0.19
13	16	-0.31	14	16	-0.50	15	16	-1.21	16	16	-1.67	17	16	-1.40	18	16	-0.96
19	16	-0.60	20	16	-0.33	21	16	-0.18	22	16	-0.13	23	16	-0.11	24	16	0.00
25	16	0.00	26	16	0.00	27	16	0.00	28	16	0.00	29	16	0.00	30	16	0.00
31	16	0.00	32	16	0.00	1	17	0.00	2	17	0.00	3	17	0.00	4	17	0.00
5	17	0.00	6	17	0.00	7	17	0.00	8	17	0.39	9	17	0.20	10	17	0.23
11	17	0.18	12	17	0.04	13	17	0.00	14	17	0.39	15	17	1.44	16	17	1.91
17	17	1.80	18	17	-0.21	19	17	-0.25	20	17	-0.17	21	17	-0.17	22	17	-0.20
23	17	-0.19	24	17	0.03	25	17	0.00	26	17	0.00	27	17	0.00	28	17	0.00
29	17	0.00	30	17	0.00	31	17	0.00	32	17	0.00	1	18	0.00	2	18	0.00
3	18	0.00	4	18	0.00	5	18	0.00	6	18	0.00	7	18	0.00	8	18	0.64
9	18	0.38	10	18	0.38	11	18	0.37	12	18	0.31	13	18	0.37	14	18	0.74
15	18	1.11	16	18	1.20	17	18	1.04	18	18	0.63	19	18	0.22	20	18	-0.06
21	18	-0.23	22	18	-0.28	23	18	-0.23	24	18	-0.01	25	18	0.00	26	18	0.00
27	18	0.00	28	18	0.00	29	18	0.00	30	18	0.00	31	18	0.00	32	18	0.00
1	19	0.00	2	19	0.00	3	19	0.00	4	19	0.00	5	19	0.00	6	19	0.00
7	19	0.00	8	19	1.09	9	19	0.76	10	19	0.51	11	19	0.39	12	19	0.37
13	19	0.42	14	19	0.54	15	19	0.63	16	19	0.60	17	19	0.45	18	19	0.26
19	19	0.05	20	19	-0.25	21	19	-0.44	22	19	-0.38	23	19	-0.20	24	19	0.00
25	19	0.00	26	19	0.00	27	19	0.00	28	19	0.00	29	19	0.00	30	19	0.00
31	19	0.00	32	19	0.00	1	20	0.00	2	20	0.00	3	20	0.00	4	20	0.00
5	20	0.00	6	20	0.00	7	20	0.00	8	20	1.59	9	20	1.26	10	20	0.74
11	20	0.38	12	20	0.27	13	20	0.25	14	20	0.18	15	20	0.05	16	20	-0.09
17	20	-0.14	18	20	-0.14	19	20	-0.22	20	20	-0.40	21	20	-0.46	22	20	-0.27
23	20	0.03	24	20	0.24	25	20	0.00	26	20	0.00	27	20	0.00	28	20	0.00
29	20	0.00	30	20	0.00	31	20	0.00	32	20	0.00	1	21	0.00	2	21	0.00
3	21	0.00	4	21	0.00	5	21	0.00	6	21	0.00	7	21	0.00	8	21	0.00
9	21	1.79	10	21	1.08	11	21	0.44	12	21	0.17	13	21	0.06	14	21	-0.08
15	21	-0.25	16	21	-0.39	17	21	-0.40	18	21	-0.34	19	21	-0.30	20	21	-0.28
21	21	-0.15	22	21	0.13	23	21	0.52	24	21	0.00	25	21	0.00	26	21	0.00
27	21	0.00	28	21	0.00	29	21	0.00	30	21	0.00	31	21	0.00	32	21	0.00
1	22	0.00	2	22	0.00	3	22	0.00	4	22	0.00	5	22	0.00	6	22	0.00
7	22	0.00	8	22	0.00	9	22	0.00	10	22	-1.10	11	22	0.63	12	22	0.38
13	22	0.12	14	22	-0.10	15	22	-0.26	16	22	-0.35	17	22	-0.35	18	22	-0.28

19	22	-0.15	20	22	0.06	21	22	0.33	22	22	0.68	23	22	0.00	24	22	0.00
25	22	0.00	26	22	0.00	27	22	0.00	28	22	0.00	29	22	0.00	30	22	0.00
31	22	0.00	32	22	0.00	1	23	0.00	2	23	0.00	3	23	0.00	4	23	0.00
5	23	0.00	6	23	0.00	7	23	0.00	8	23	0.00	9	23	0.00	10	23	0.00
11	23	2.40	12	23	1.27	13	23	0.63	14	23	0.10	15	23	-0.25	16	23	-0.33
17	23	-0.21	18	23	0.00	19	23	0.23	20	23	0.51	21	23	0.82	22	23	0.00
23	23	0.00	24	23	0.00	25	23	0.00	26	23	0.00	27	23	0.00	28	23	0.00
29	23	0.00	30	23	0.00	31	23	0.00	32	23	0.00	1	24	0.00	2	24	0.00
3	24	0.00	4	24	0.00	5	24	0.00	6	24	0.00	7	24	0.00	8	24	0.00
9	24	0.00	10	24	0.00	11	24	0.00	12	24	2.77	13	24	2.11	14	24	-0.07
15	24	-1.06	16	24	-1.16	17	24	-0.61	18	24	0.73	19	24	1.14	20	24	1.32
21	24	0.00	22	24	0.00	23	24	0.00	24	24	0.00	25	24	0.00	26	24	0.00
27	24	0.00	28	24	0.00	29	24	0.00	30	24	0.00	31	24	0.00	32	24	0.00
1	25	0.00	2	25	0.00	3	25	0.00	4	25	0.00	5	25	0.00	6	25	0.00
7	25	0.00	8	25	0.00	9	25	0.00	10	25	0.00	11	25	0.00	12	25	0.00
13	25	0.00	14	25	0.00	15	25	0.00	16	25	0.00	17	25	0.00	18	25	0.00
19	25	0.00	20	25	0.00	21	25	0.00	22	25	0.00	23	25	0.00	24	25	0.00
25	25	0.00	26	25	0.00	27	25	0.00	28	25	0.00	29	25	0.00	30	25	0.00
31	25	0.00	32	25	0.00	1	26	0.00	2	26	0.00	3	26	0.00	4	26	0.00
5	26	0.00	6	26	0.00	7	26	0.00	8	26	0.00	9	26	0.00	10	26	0.00
11	26	0.00	12	26	0.00	13	26	0.00	14	26	0.00	15	26	0.00	16	26	0.00
17	26	0.00	18	26	0.00	19	26	0.00	20	26	0.00	21	26	0.00	22	26	0.00
23	26	0.00	24	26	0.00	25	26	0.00	26	26	0.00	27	26	0.00	28	26	0.00
29	26	0.00	30	26	0.00	31	26	0.00	32	26	0.00	1	27	0.00	2	27	0.00
3	27	0.00	4	27	0.00	5	27	0.00	6	27	0.00	7	27	0.00	8	27	0.00
9	27	0.00	10	27	0.00	11	27	0.00	12	27	0.00	13	27	0.00	14	27	0.00
15	27	0.00	16	27	0.00	17	27	0.00	18	27	0.00	19	27	0.00	20	27	0.00
21	27	0.00	22	27	0.00	23	27	0.00	24	27	0.00	25	27	0.00	26	27	0.00
27	27	0.00	28	27	0.00	29	27	0.00	30	27	0.00	31	27	0.00	32	27	0.00
1	28	0.00	2	28	0.00	3	28	0.00	4	28	0.00	5	28	0.00	6	28	0.00
7	28	0.00	8	28	0.00	9	28	0.00	10	28	0.00	11	28	0.00	12	28	0.00
13	28	0.00	14	28	0.00	15	28	0.00	16	28	0.00	17	28	0.00	18	28	0.00
19	28	0.00	20	28	0.00	21	28	0.00	22	28	0.00	23	28	0.00	24	28	0.00
25	28	0.00	26	28	0.00	27	28	0.00	28	28	0.00	29	28	0.00	30	28	0.00
31	28	0.00	32	28	0.00	1	29	0.00	2	29	0.00	3	29	0.00	4	29	0.00
5	29	0.00	6	29	0.00	7	29	0.00	8	29	0.00	9	29	0.00	10	29	0.00
11	29	0.00	12	29	0.00	13	29	0.00	14	29	0.00	15	29	0.00	16	29	0.00
17	29	0.00	18	29	0.00	19	29	0.00	20	29	0.00	21	29	0.00	22	29	0.00
23	29	0.00	24	29	0.00	25	29	0.00	26	29	0.00	27	29	0.00	28	29	0.00
29	29	0.00	30	29	0.00	31	29	0.00	32	29	0.00	1	30	0.00	2	30	0.00
3	30	0.00	4	30	0.00	5	30	0.00	6	30	0.00	7	30	0.00	8	30	0.00
9	30	0.00	10	30	0.00	11	30	0.00	12	30	0.00	13	30	0.00	14	30	0.00
15	30	0.00	16	30	0.00	17	30	0.00	18	30	0.00	19	30	0.00	20	30	0.00
21	30	0.00	22	30	0.00	23	30	0.00	24	30	0.00	25	30	0.00	26	30	0.00
27	30	0.00	28	30	0.00	29	30	0.00	30	30	0.00	31	30	0.00	32	30	0.00
1	31	0.00	2	31	0.00	3	31	0.00	4	31	0.00	5	31	0.00	6	31	0.00
7	31	0.00	8	31	0.00	9	31	0.00	10	31	0.00	11	31	0.00	12	31	0.00
13	31	0.00	14	31	0.00	15	31	0.00	16	31	0.00	17	31	0.00	18	31	0.00
19	31	0.00	20	31	0.00	21	31	0.00	22	31	0.00	23	31	0.00	24	31	0.00
25	31	0.00	26	31	0.00	27	31	0.00	28	31	0.00	29	31	0.00	30	31	0.00
31	31	0.00	32	31	0.00	1	32	0.00	2	32	0.00	3	32	0.00	4	32	0.00
5	32	0.00	6	32	0.00	7	32	0.00	8	32	0.00	9	32	0.00	10	32	0.00
11	32	0.00	12	32	0.00	13	32	0.00	14	32	0.00	15	32	0.00	16	32	0.00
17	32	0.00	18	32	0.00	19	32	0.00	20	32	0.00	21	32	0.00	22	32	0.00
23	32	0.00	24	32	0.00	25	32	0.00	26	32	0.00	27	32	0.00	28	32	0.00
29	32	0.00	30	32	0.00	31	32	0.00	32	32	0.00						

TABLE 2

Aperture phase results for 1986 (H01124AV1.phase)

1	1	0.00	2	1	0.00	3	1	0.00	4	1	0.00	5	1	0.00	6	1	0.00
7	1	0.00	8	1	0.00	9	1	0.00	10	1	0.00	11	1	0.00	12	1	0.00
13	1	0.00	14	1	0.00	15	1	0.00	16	1	0.00	17	1	0.00	18	1	0.00
19	1	0.00	20	1	0.00	21	1	0.00	22	1	0.00	23	1	0.00	24	1	0.00
25	1	0.00	26	1	0.00	27	1	0.00	28	1	0.00	29	1	0.00	30	1	0.00
31	1	0.00	32	1	0.00	1	2	0.00	2	2	0.00	3	2	0.00	4	2	0.00
5	2	0.00	6	2	0.00	7	2	0.00	8	2	0.00	9	2	0.00	10	2	0.00
11	2	0.00	12	2	0.00	13	2	0.00	14	2	0.00	15	2	0.00	16	2	0.00
17	2	0.00	18	2	0.00	19	2	0.00	20	2	0.00	21	2	0.00	22	2	0.00
23	2	0.00	24	2	0.00	25	2	0.00	26	2	0.00	27	2	0.00	28	2	0.00
29	2	0.00	30	2	0.00	31	2	0.00	32	2	0.00	1	3	0.00	2	3	0.00
3	3	0.00	4	3	0.00	5	3	0.00	6	3	0.00	7	3	0.00	8	3	0.00
9	3	0.00	10	3	0.00	11	3	0.00	12	3	0.00	13	3	0.00	14	3	0.00
15	3	0.00	16	3	0.00	17	3	0.00	18	3	0.00	19	3	0.00	20	3	0.00
21	3	0.00	22	3	0.00	23	3	0.00	24	3	0.00	25	3	0.00	26	3	0.00
27	3	0.00	28	3	0.00	29	3	0.00	30	3	0.00	31	3	0.00	32	3	0.00
1	4	0.00	2	4	0.00	3	4	0.00	4	4	0.00	5	4	0.00	6	4	0.00
7	4	0.00	8	4	0.00	9	4	0.00	10	4	0.00	11	4	0.00	12	4	0.00
13	4	0.00	14	4	0.00	15	4	0.00	16	4	0.00	17	4	0.00	18	4	0.00
19	4	0.00	20	4	0.00	21	4	0.00	22	4	0.00	23	4	0.00	24	4	0.00
25	4	0.00	26	4	0.00	27	4	0.00	28	4	0.00	29	4	0.00	30	4	0.00
31	4	0.00	32	4	0.00	1	5	0.00	2	5	0.00	3	5	0.00	4	5	0.00
5	5	0.00	6	5	0.00	7	5	0.00	8	5	0.00	9	5	0.00	10	5	0.00
11	5	0.00	12	5	0.00	13	5	0.00	14	5	0.00	15	5	0.00	16	5	0.00
17	5	0.00	18	5	0.00	19	5	0.00	20	5	0.00	21	5	0.00	22	5	0.00
23	5	0.00	24	5	0.00	25	5	0.00	26	5	0.00	27	5	0.00	28	5	0.00
29	5	0.00	30	5	0.00	31	5	0.00	32	5	0.00	1	6	0.00	2	6	0.00
3	6	0.00	4	6	0.00	5	6	0.00	6	6	0.00	7	6	0.00	8	6	0.00
9	6	0.00	10	6	0.00	11	6	0.00	12	6	0.00	13	6	0.00	14	6	0.00
15	6	0.00	16	6	0.00	17	6	0.00	18	6	0.00	19	6	0.00	20	6	0.00
21	6	0.00	22	6	0.00	23	6	0.00	24	6	0.00	25	6	0.00	26	6	0.00
27	6	0.00	28	6	0.00	29	6	0.00	30	6	0.00	31	6	0.00	32	6	0.00
1	7	0.00	2	7	0.00	3	7	0.00	4	7	0.00	5	7	0.00	6	7	0.00
7	7	0.00	8	7	0.00	9	7	0.00	10	7	0.00	11	7	0.00	12	7	0.00
13	7	0.00	14	7	0.00	15	7	0.00	16	7	0.00	17	7	0.00	18	7	0.00
19	7	0.00	20	7	0.00	21	7	0.00	22	7	0.00	23	7	0.00	24	7	0.00
25	7	0.00	26	7	0.00	27	7	0.00	28	7	0.00	29	7	0.00	30	7	0.00
31	7	0.00	32	7	0.00	1	8	0.00	2	8	0.00	3	8	0.00	4	8	0.00
5	8	0.00	6	8	0.00	7	8	0.00	8	8	0.00	9	8	0.00	10	8	0.00
11	8	0.00	12	8	2.14	13	8	0.86	14	8	-0.39	15	8	-0.31	16	8	-0.24
17	8	-0.21	18	8	-0.25	19	8	-0.31	20	8	-0.31	21	8	0.00	22	8	0.00
23	8	0.00	24	8	0.00	25	8	0.00	26	8	0.00	27	8	0.00	28	8	0.00
29	8	0.00	30	8	0.00	31	8	0.00	32	8	0.00	1	9	0.00	2	9	0.00
3	9	0.00	4	9	0.00	5	9	0.00	6	9	0.00	7	9	0.00	8	9	0.00
9	9	0.00	10	9	0.00	11	9	-2.07	12	9	-1.44	13	9	-0.87	14	9	-0.30
15	9	-0.06	16	9	-0.01	17	9	-0.02	18	9	-0.07	19	9	-0.19	20	9	-0.35
21	9	-0.42	22	9	0.00	23	9	0.00	24	9	0.00	25	9	0.00	26	9	0.00
27	9	0.00	28	9	0.00	29	9	0.00	30	9	0.00	31	9	0.00	32	9	0.00
1	10	0.00	2	10	0.00	3	10	0.00	4	10	0.00	5	10	0.00	6	10	0.00
7	10	0.00	8	10	0.00	9	10	0.00	10	10	-1.12	11	10	-0.91	12	10	-0.73
13	10	-0.51	14	10	-0.17	15	10	0.09	16	10	0.15	17	10	0.10	18	10	0.03
19	10	-0.03	20	10	-0.08	21	10	-0.10	22	10	0.04	23	10	0.00	24	10	0.00
25	10	0.00	26	10	0.00	27	10	0.00	28	10	0.00	29	10	0.00	30	10	0.00
31	10	0.00	32	10	0.00	1	11	0.00	2	11	0.00	3	11	0.00	4	11	0.00
5	11	0.00	6	11	0.00	7	11	0.00	8	11	0.00	9	11	-0.82	10	11	-0.61
11	11	-0.47	12	11	-0.37	13	11	-0.28	14	11	-0.13	15	11	0.01	16	11	0.05
17	11	0.01	18	11	-0.01	19	11	0.03	20	11	0.11	21	11	0.16	22	11	0.19

23	11	0.36	24	11	0.00	25	11	0.00	26	11	0.00	27	11	0.00	28	11	0.00
29	11	0.00	30	11	0.00	31	11	0.00	32	11	0.00	1	12	0.00	2	12	0.00
3	12	0.00	4	12	0.00	5	12	0.00	6	12	0.00	7	12	0.00	8	12	-0.74
9	12	-0.47	10	12	-0.30	11	12	-0.19	12	12	-0.14	13	12	-0.11	14	12	-0.11
15	12	-0.13	16	12	-0.14	17	12	-0.13	18	12	-0.10	19	12	-0.01	20	12	0.14
21	12	0.24	22	12	0.24	23	12	0.28	24	12	0.65	25	12	0.00	26	12	0.00
27	12	0.00	28	12	0.00	29	12	0.00	30	12	0.00	31	12	0.00	32	12	0.00
1	13	0.00	2	13	0.00	3	13	0.00	4	13	0.00	5	13	0.00	6	13	0.00
7	13	0.00	8	13	-0.44	9	13	-0.23	10	13	-0.08	11	13	0.00	12	13	0.01
13	13	-0.03	14	13	-0.13	15	13	-0.20	16	13	-0.21	17	13	-0.18	18	13	-0.13
19	13	-0.03	20	13	0.13	21	13	0.25	22	13	0.26	23	13	0.27	24	13	0.59
25	13	0.00	26	13	0.00	27	13	0.00	28	13	0.00	29	13	0.00	30	13	0.00
31	13	0.00	32	13	0.00	1	14	0.00	2	14	0.00	3	14	0.00	4	14	0.00
5	14	0.00	6	14	0.00	7	14	0.00	8	14	-0.22	9	14	-0.06	10	14	0.04
11	14	0.08	12	14	0.04	13	14	-0.06	14	14	-0.19	15	14	-0.25	16	14	-0.25
17	14	-0.20	18	14	-0.12	19	14	0.03	20	14	0.23	21	14	0.34	22	14	0.35
23	14	0.35	24	14	0.66	25	14	0.00	26	14	0.00	27	14	0.00	28	14	0.00
29	14	0.00	30	14	0.00	31	14	0.00	32	14	0.00	1	15	0.00	2	15	0.00
3	15	0.00	4	15	0.00	5	15	0.00	6	15	0.00	7	15	0.00	8	15	0.03
9	15	0.06	10	15	0.08	11	15	0.07	12	15	0.00	13	15	-0.12	14	15	-0.23
15	15	-0.29	16	15	-0.28	17	15	-0.19	18	15	-0.03	19	15	0.20	20	15	0.39
21	15	0.47	22	15	0.46	23	15	0.45	24	15	0.83	25	15	0.00	26	15	0.00
27	15	0.00	28	15	0.00	29	15	0.00	30	15	0.00	31	15	0.00	32	15	0.00
1	16	0.00	2	16	0.00	3	16	0.00	4	16	0.00	5	16	0.00	6	16	0.00
7	16	0.00	8	16	0.40	9	16	0.23	10	16	0.15	11	16	0.09	12	16	0.02
13	16	-0.04	14	16	-0.10	15	16	-0.16	16	16	-0.14	17	16	0.02	18	16	0.20
19	16	0.33	20	16	0.43	21	16	0.46	22	16	0.43	23	16	0.46	24	16	0.89
25	16	0.00	26	16	0.00	27	16	0.00	28	16	0.00	29	16	0.00	30	16	0.00
31	16	0.00	32	16	0.00	1	17	0.00	2	17	0.00	3	17	0.00	4	17	0.00
5	17	0.00	6	17	0.00	7	17	0.00	8	17	0.73	9	17	0.46	10	17	0.32
11	17	0.21	12	17	0.17	13	17	0.21	14	17	0.27	15	17	0.29	16	17	0.27
17	17	0.31	18	17	0.32	19	17	0.28	20	17	0.23	21	17	0.20	22	17	0.21
23	17	0.34	24	17	0.77	25	17	0.00	26	17	0.00	27	17	0.00	28	17	0.00
29	17	0.00	30	17	0.00	31	17	0.00	32	17	0.00	1	18	0.00	2	18	0.00
3	18	0.00	4	18	0.00	5	18	0.00	6	18	0.00	7	18	0.00	8	18	0.86
9	18	0.62	10	18	0.45	11	18	0.32	12	18	0.28	13	18	0.33	14	18	0.38
15	18	0.35	16	18	0.28	17	18	0.26	18	18	0.20	19	18	0.06	20	18	-0.10
21	18	-0.19	22	18	-0.09	23	18	0.21	24	18	0.62	25	18	0.00	26	18	0.00
27	18	0.00	28	18	0.00	29	18	0.00	30	18	0.00	31	18	0.00	32	18	0.00
1	19	0.00	2	19	0.00	3	19	0.00	4	19	0.00	5	19	0.00	6	19	0.00
7	19	0.00	8	19	0.97	9	19	0.69	10	19	0.45	11	19	0.27	12	19	0.19
13	19	0.19	14	19	0.17	15	19	0.11	16	19	0.06	17	19	0.02	18	19	-0.06
19	19	-0.22	20	19	-0.40	21	19	-0.46	22	19	-0.25	23	19	0.19	24	19	0.50
25	19	0.00	26	19	0.00	27	19	0.00	28	19	0.00	29	19	0.00	30	19	0.00
31	19	0.00	32	19	0.00	1	20	0.00	2	20	0.00	3	20	0.00	4	20	0.00
5	20	0.00	6	20	0.00	7	20	0.00	8	20	1.20	9	20	0.73	10	20	0.37
11	20	0.12	12	20	0.01	13	20	-0.04	14	20	-0.08	15	20	-0.11	16	20	-0.14
17	20	-0.21	18	20	-0.33	19	20	-0.48	20	20	-0.57	21	20	-0.50	22	20	-0.14
23	20	0.36	24	20	0.45	25	20	0.00	26	20	0.00	27	20	0.00	28	20	0.00
29	20	0.00	30	20	0.00	31	20	0.00	32	20	0.00	1	21	0.00	2	21	0.00
3	21	0.00	4	21	0.00	5	21	0.00	6	21	0.00	7	21	0.00	8	21	0.00
9	21	0.81	10	21	0.32	11	21	0.05	12	21	-0.10	13	21	-0.19	14	21	-0.22
15	21	-0.22	16	21	-0.24	17	21	-0.34	18	21	-0.49	19	21	-0.58	20	21	-0.52
21	21	-0.23	22	21	0.34	23	21	0.81	24	21	0.00	25	21	0.00	26	21	0.00
27	21	0.00	28	21	0.00	29	21	0.00	30	21	0.00	31	21	0.00	32	21	0.00
1	22	0.00	2	22	0.00	3	22	0.00	4	22	0.00	5	22	0.00	6	22	0.00
7	22	0.00	8	22	0.00	9	22	0.00	10	22	0.56	11	22	0.23	12	22	0.01
13	22	-0.14	14	22	-0.18	15	22	-0.17	16	22	-0.22	17	22	-0.36	18	22	-0.48

19	22	-0.46	20	22	-0.21	21	22	0.27	22	22	0.80	23	22	0.00	24	22	0.00
25	22	0.00	26	22	0.00	27	22	0.00	28	22	0.00	29	22	0.00	30	22	0.00
31	22	0.00	32	22	0.00	1	23	0.00	2	23	0.00	3	23	0.00	4	23	0.00
5	23	0.00	6	23	0.00	7	23	0.00	8	23	0.00	9	23	0.00	10	23	0.00
11	23	2.09	12	23	1.01	13	23	0.47	14	23	0.25	15	23	0.05	16	23	-0.22
17	23	-0.38	18	23	-0.37	19	23	-0.20	20	23	0.08	21	23	0.29	22	23	0.00
23	23	0.00	24	23	0.00	25	23	0.00	26	23	0.00	27	23	0.00	28	23	0.00
29	23	0.00	30	23	0.00	31	23	0.00	32	23	0.00	1	24	0.00	2	24	0.00
3	24	0.00	4	24	0.00	5	24	0.00	6	24	0.00	7	24	0.00	8	24	0.00
9	24	0.00	10	24	0.00	11	24	0.00	12	24	2.87	13	24	2.41	14	24	2.51
15	24	-1.98	16	24	-1.08	17	24	-0.68	18	24	-0.38	19	24	-0.13	20	24	0.00
21	24	0.00	22	24	0.00	23	24	0.00	24	24	0.00	25	24	0.00	26	24	0.00
27	24	0.00	28	24	0.00	29	24	0.00	30	24	0.00	31	24	0.00	32	24	0.00
1	25	0.00	2	25	0.00	3	25	0.00	4	25	0.00	5	25	0.00	6	25	0.00
7	25	0.00	8	25	0.00	9	25	0.00	10	25	0.00	11	25	0.00	12	25	0.00
13	25	0.00	14	25	0.00	15	25	0.00	16	25	0.00	17	25	0.00	18	25	0.00
19	25	0.00	20	25	0.00	21	25	0.00	22	25	0.00	23	25	0.00	24	25	0.00
25	25	0.00	26	25	0.00	27	25	0.00	28	25	0.00	29	25	0.00	30	25	0.00
31	25	0.00	32	25	0.00	1	26	0.00	2	26	0.00	3	26	0.00	4	26	0.00
5	26	0.00	6	26	0.00	7	26	0.00	8	26	0.00	9	26	0.00	10	26	0.00
11	26	0.00	12	26	0.00	13	26	0.00	14	26	0.00	15	26	0.00	16	26	0.00
17	26	0.00	18	26	0.00	19	26	0.00	20	26	0.00	21	26	0.00	22	26	0.00
23	26	0.00	24	26	0.00	25	26	0.00	26	26	0.00	27	26	0.00	28	26	0.00
29	26	0.00	30	26	0.00	31	26	0.00	32	26	0.00	1	27	0.00	2	27	0.00
3	27	0.00	4	27	0.00	5	27	0.00	6	27	0.00	7	27	0.00	8	27	0.00
9	27	0.00	10	27	0.00	11	27	0.00	12	27	0.00	13	27	0.00	14	27	0.00
15	27	0.00	16	27	0.00	17	27	0.00	18	27	0.00	19	27	0.00	20	27	0.00
21	27	0.00	22	27	0.00	23	27	0.00	24	27	0.00	25	27	0.00	26	27	0.00
27	27	0.00	28	27	0.00	29	27	0.00	30	27	0.00	31	27	0.00	32	27	0.00
1	28	0.00	2	28	0.00	3	28	0.00	4	28	0.00	5	28	0.00	6	28	0.00
7	28	0.00	8	28	0.00	9	28	0.00	10	28	0.00	11	28	0.00	12	28	0.00
13	28	0.00	14	28	0.00	15	28	0.00	16	28	0.00	17	28	0.00	18	28	0.00
19	28	0.00	20	28	0.00	21	28	0.00	22	28	0.00	23	28	0.00	24	28	0.00
25	28	0.00	26	28	0.00	27	28	0.00	28	28	0.00	29	28	0.00	30	28	0.00
31	28	0.00	32	28	0.00	1	29	0.00	2	29	0.00	3	29	0.00	4	29	0.00
5	29	0.00	6	29	0.00	7	29	0.00	8	29	0.00	9	29	0.00	10	29	0.00
11	29	0.00	12	29	0.00	13	29	0.00	14	29	0.00	15	29	0.00	16	29	0.00
17	29	0.00	18	29	0.00	19	29	0.00	20	29	0.00	21	29	0.00	22	29	0.00
23	29	0.00	24	29	0.00	25	29	0.00	26	29	0.00	27	29	0.00	28	29	0.00
29	29	0.00	30	29	0.00	31	29	0.00	32	29	0.00	1	30	0.00	2	30	0.00
3	30	0.00	4	30	0.00	5	30	0.00	6	30	0.00	7	30	0.00	8	30	0.00
9	30	0.00	10	30	0.00	11	30	0.00	12	30	0.00	13	30	0.00	14	30	0.00
15	30	0.00	16	30	0.00	17	30	0.00	18	30	0.00	19	30	0.00	20	30	0.00
21	30	0.00	22	30	0.00	23	30	0.00	24	30	0.00	25	30	0.00	26	30	0.00
27	30	0.00	28	30	0.00	29	30	0.00	30	30	0.00	31	30	0.00	32	30	0.00
1	31	0.00	2	31	0.00	3	31	0.00	4	31	0.00	5	31	0.00	6	31	0.00
7	31	0.00	8	31	0.00	9	31	0.00	10	31	0.00	11	31	0.00	12	31	0.00
13	31	0.00	14	31	0.00	15	31	0.00	16	31	0.00	17	31	0.00	18	31	0.00
19	31	0.00	20	31	0.00	21	31	0.00	22	31	0.00	23	31	0.00	24	31	0.00
25	31	0.00	26	31	0.00	27	31	0.00	28	31	0.00	29	31	0.00	30	31	0.00
31	31	0.00	32	31	0.00	1	32	0.00	2	32	0.00	3	32	0.00	4	32	0.00
5	32	0.00	6	32	0.00	7	32	0.00	8	32	0.00	9	32	0.00	10	32	0.00
11	32	0.00	12	32	0.00	13	32	0.00	14	32	0.00	15	32	0.00	16	32	0.00
17	32	0.00	18	32	0.00	19	32	0.00	20	32	0.00	21	32	0.00	22	32	0.00
23	32	0.00	24	32	0.00	25	32	0.00	26	32	0.00	27	32	0.00	28	32	0.00
29	32	0.00	30	32	0.00	31	32	0.00	32	32	0.00						

FIGURE 1

VENUS MAY 1990 WITH PLASTIC ELEVATION 46.5°
303229311 SOLN. PHASE (RAD) -0.800.80 0.20

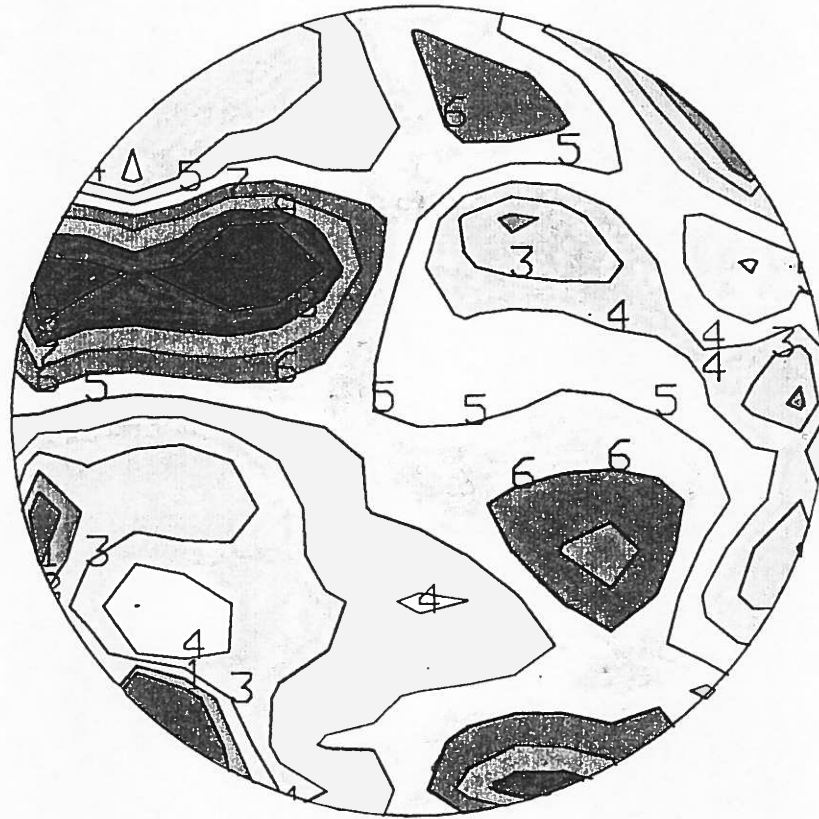


FIGURE 2

VENUS MAY 1990 AVERAGE(3) ELEVATION 44°
174218432 SOLN. PHASE (RAD) -0.800.80 0.20

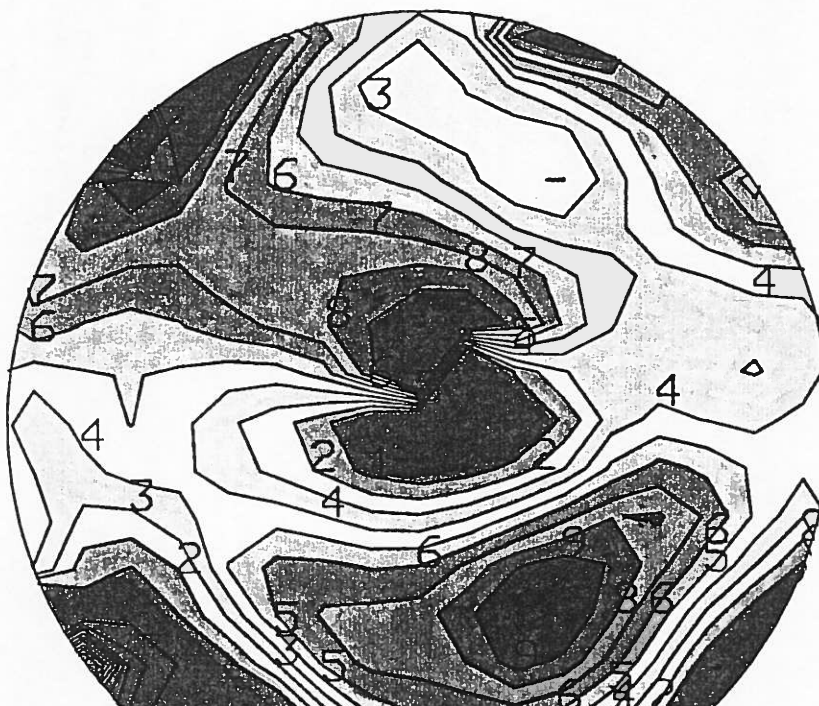


FIGURE 3

JUPITER MAY 1990 ELEVATION 66.7°

H34H35003 SOLN. PHASE (RAD) -0.800.80 0.20

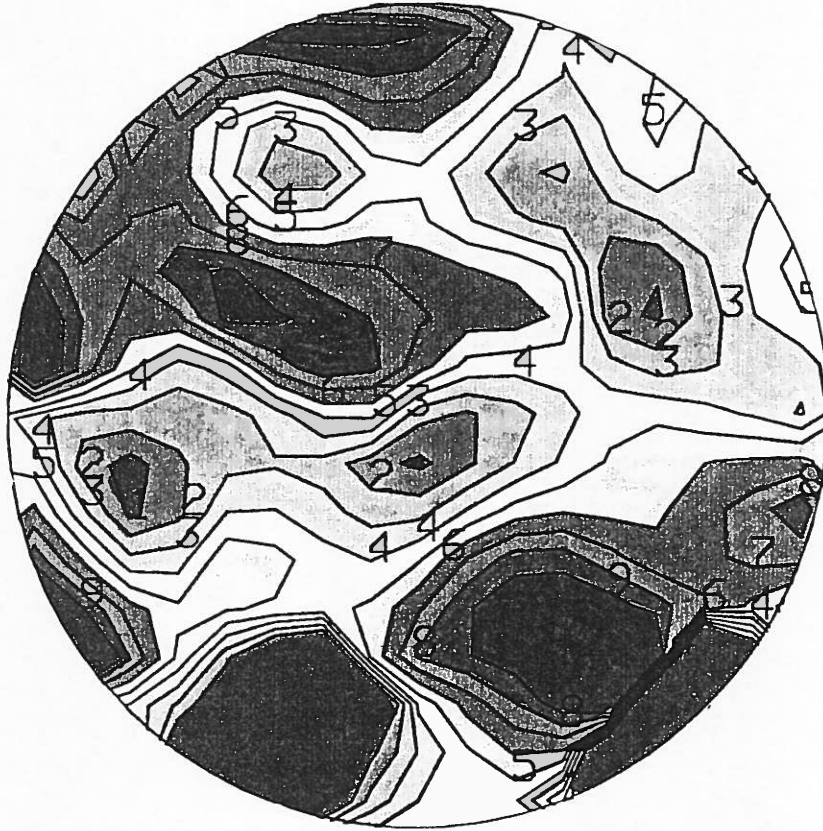


FIGURE 4

JUPITER MAY 1990 ELEVATION 35.7°

H40H41002 SOLN. PHASE (RAD) -0.800.80 0.20

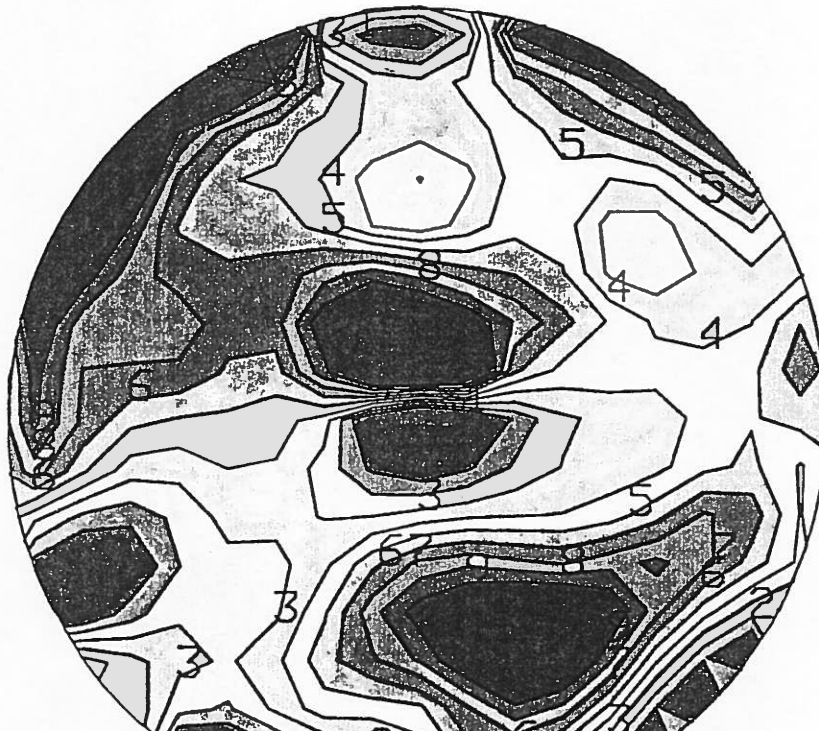
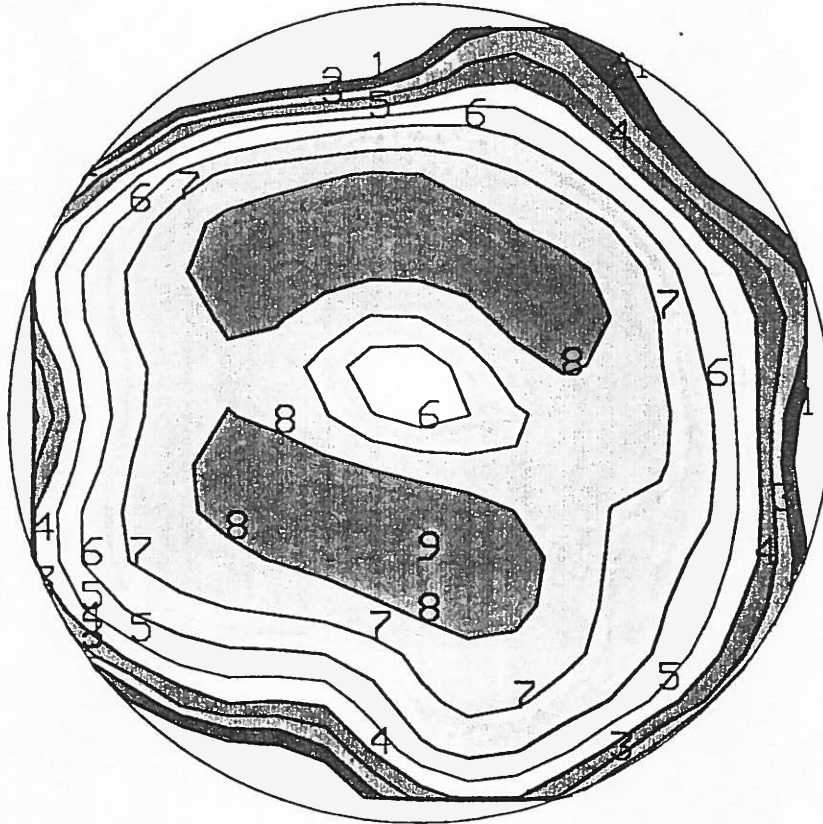


FIGURE 5

VENUS 1986 DATA ELEVATION 35°

HO1124AV1 AV. APERTURE POWER (DB) -16.00.0 2.0



HO1124AV1 AV. PHASE (RAD) -0.800.80 0.20

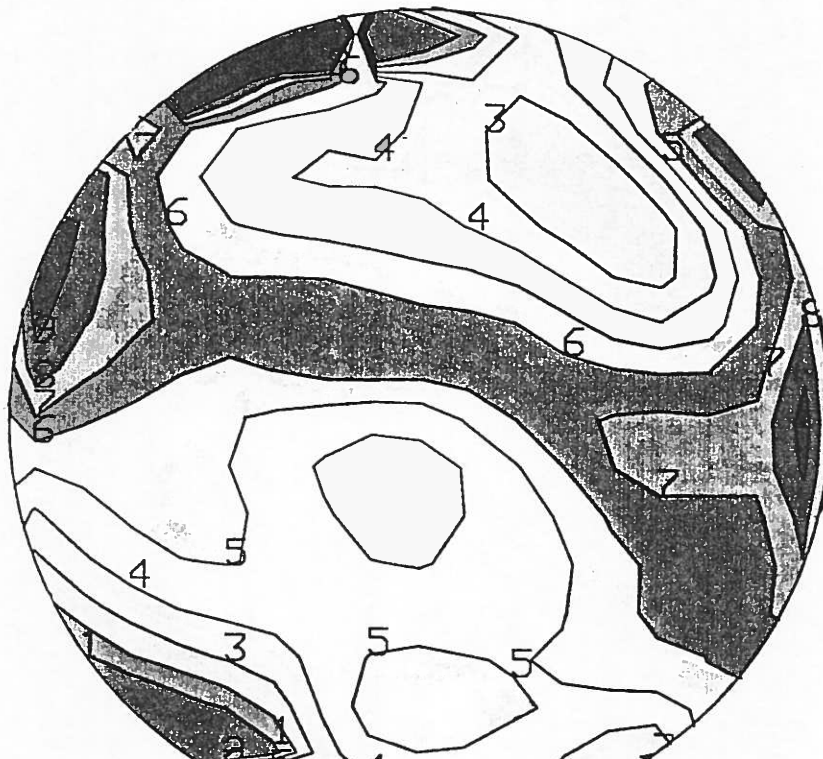
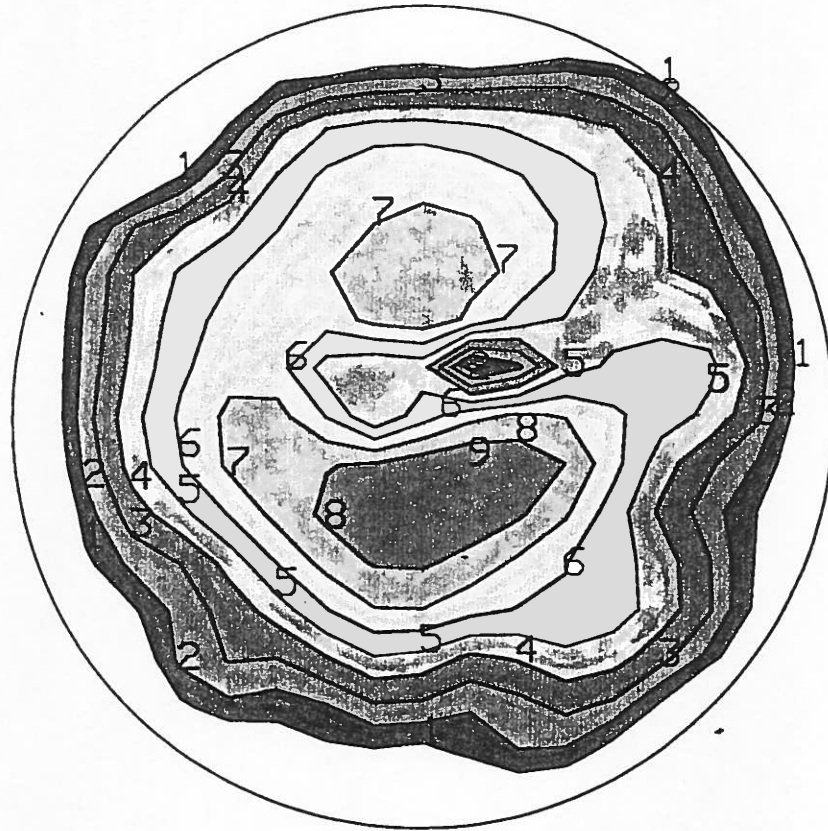


FIGURE 6

VENJUPAV2 AV. APERTURE POWER (DB) -16.00.0 2.0



VENJUPAV2 AV. PHASE (RAD) -0.800.80 0.20

